

Camera Applications with libcamera and PipeWire



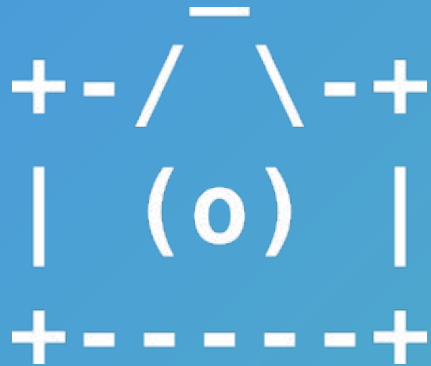
Embedded Open Source Summit
Prague 2023

~~Kieran Bingham~~

Daniel Scally

dan.scally@ideasonboard.com





“libcamera exists, please use it.”



+ - / \ - +
| (o) |
+ - - - - +

- Hi, I'm Dan
- libcamera
- Applications
- Demo
- Summary
- Q+A



+ - / \ - +
| (o) |
+ - - - - +

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```
camera@1 {  
    ...  
  
    port@0 {  
        ...  
  
        camera_csi_out: endpoint@0 {  
            remote-endpoint = <&isp_csi_in>;  
        };  
    };  
};  
  
isp@0 {  
    ...  
  
    port@0 {  
        ...  
        isp_in: endpoint@0 {  
            remote-endpoint = <&camera_csi_out>;  
        };  
    };  
};
```



How it works with DT

```

Device (ISP)
{
    Name (_DSD, Package () {
        ToUUID("dbb8e3e6-5886-4ba6-8795-1319f52a966b"),
        Package () {
            Package () { "port@0", "PRT0" },
        }
    })

    Name (PRT0, Package() {
        ToUUID("daffd814-6eba-4d8c-8a91-bc9bbf4aa301"),
        Package () {
            Package () { "reg", 0 }, /* CSI-2 port number */
        },
        ToUUID("dbb8e3e6-5886-4ba6-8795-1319f52a966b"),
        Package () {
            Package () { "endpoint@0", "EP00" },
        }
    })

    Name (EP00, Package() {
        ToUUID("daffd814-6eba-4d8c-8a91-bc9bbf4aa301"),
        Package () {
            Package () { "reg", 0 },
            Package () { "remote-endpoint", Package () { \_SB.PCI0.I2C2.CAM0,
"port@0", "endpoint@0" } },
        }
    })
}

```

```

Device (CAM0)
{
    Name (_DSD, Package () {
        ToUUID("daffd814-6eba-4d8c-8a91-bc9bbf4aa301"),
        Package () {
            Package () { "compatible", Package () { "nokia,smia" } },
        },
        ToUUID("dbb8e3e6-5886-4ba6-8795-1319f52a966b"),
        Package () {
            Package () { "port@0", "PRT0" },
        }
    })

    Name (PRT0, Package() {
        ToUUID("daffd814-6eba-4d8c-8a91-bc9bbf4aa301"),
        Package () {
            Package () { "reg", 0 },
        },
        ToUUID("dbb8e3e6-5886-4ba6-8795-1319f52a966b"),
        Package () {
            Package () { "endpoint@0", "EP00" },
        }
    })

    Name (EP00, Package() {
        ToUUID("daffd814-6eba-4d8c-8a91-bc9bbf4aa301"),
        Package () {
            Package () { "reg", 0 },
            Package () { "remote-endpoint", Package() { \_SB.PCI0.ISP,
"port@0", "endpoint@0" } },
        }
    })
}

```



How it's supposed to work on ACPI

Device (CIO2)

```
{
    Name (_HID, "INT343E") // The CSI-2 Receiver

    ... and no ports / endpoints at all...
}
```

Device (CAM0)

```
{
    Name (_HID, "INT33BE" /* Camera Sensor OV5693 */)

    Method (SSDB, 0, NotSerialized)
    {
        Name (PAR, Buffer (0x6C))
        {
            /* 0000 */ 0x00, 0x20, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0008 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0010 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0018 */ 0x00, 0x00, 0x00, 0x00, 0x01, 0x02, 0x00, 0x00, // .....
            /* 0020 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0028 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0030 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0038 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0040 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0048 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x01, 0x00, // .....
            /* 0050 */ 0x09, 0x00, 0x02, 0x01, 0x01, 0x01, 0x00, 0xF8, // .....
            /* 0058 */ 0x24, 0x01, 0x01, 0x00, 0x00, 0x00, 0x00, 0x00, // $......
            /* 0060 */ 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, // .....
            /* 0068 */ 0x00, 0x00, 0x00, 0x00 // ....
        })
        Return (PAR) /* \_SB_.PCI0.I2C2.CAM0.SSDB.PAR_ */
    }
}
```

/* Data representation as it is in ACPI SSDB buffer */

```
struct cio2_sensor_ssdb {
    u8 version;
    u8 sku;
    u8 guid_csi2[16];
    u8 devfunction;
    u8 bus;
    u32 dphylinkenfuses;
    u32 clockdiv;
    u8 link;
    u8 lanes;
    u32 csiparams[10];
    u32 maxlanespeed;
    u8 sensorcalibfileidx;
    u8 sensorcalibfileidxlnMBZ[3];
    u8 romtype;
    u8 vcmttype;
    u8 platforminfo;
    u8 platformsubinfo;
    u8 flash;
    u8 privacyled;
    u8 degree;
    u8 mipilinkdefined;
    u32 mclkspeed;
    u8 controllogicid;
    u8 reserved1[3];
    u8 mclkport;
    u8 reserved2[13];
} __packed;
```



How it actually works


```

struct property_entry cio2_properties[] = {
    PROPERTY_ENTRY_REF(
        "remote-endpoint",
        &sensor_endpoint),
};

struct software_node cio2_node = {
    .name = "int343e",
};

struct software_node cio2_port = {
    .name = "port@0",
    .parent = &cio2_node,
};

struct software_node cio2_endpoint = {
    .name = "endpoint@0",
    .parent = &cio2_port,
    .properties = cio2_properties,
};

```

```

struct property_entry sensor_properties[] = {
    PROPERTY_ENTRY_REF(
        "remote-endpoint",
        &cio2_endpoint),
};

struct software_node sensor_node = {
    .name = "int33be",
};

struct software_node sensor_port = {
    .name = "port@0",
    .parent = &sensor_node,
};

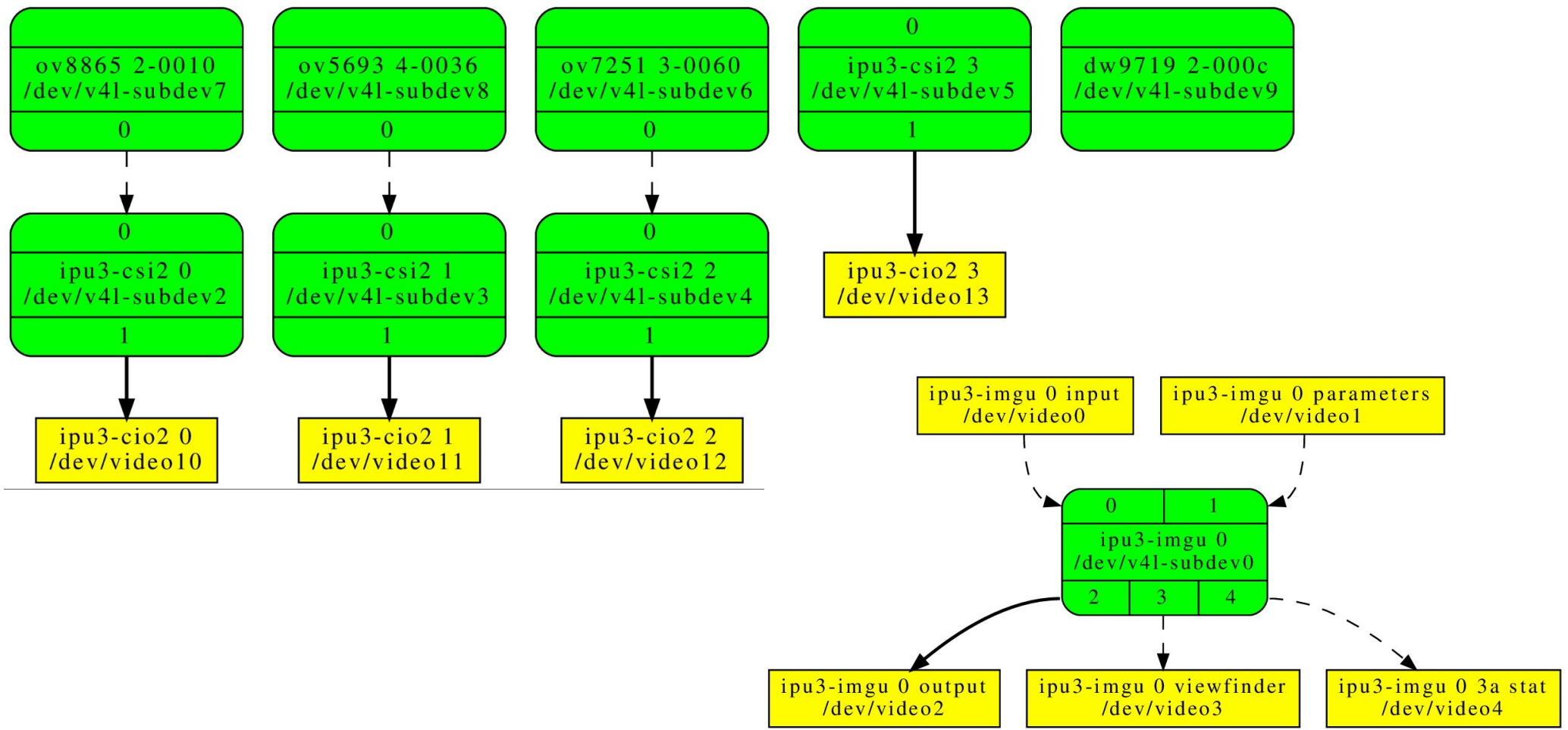
struct software_node sensor_endpoint = {
    .name = "endpoint@0",
    .parent = &sensor_port,
    .properties = sensor_properties,
};

```

drivers/media/pci/intel/ipu3/cio2-bridge.c



How we fixed it

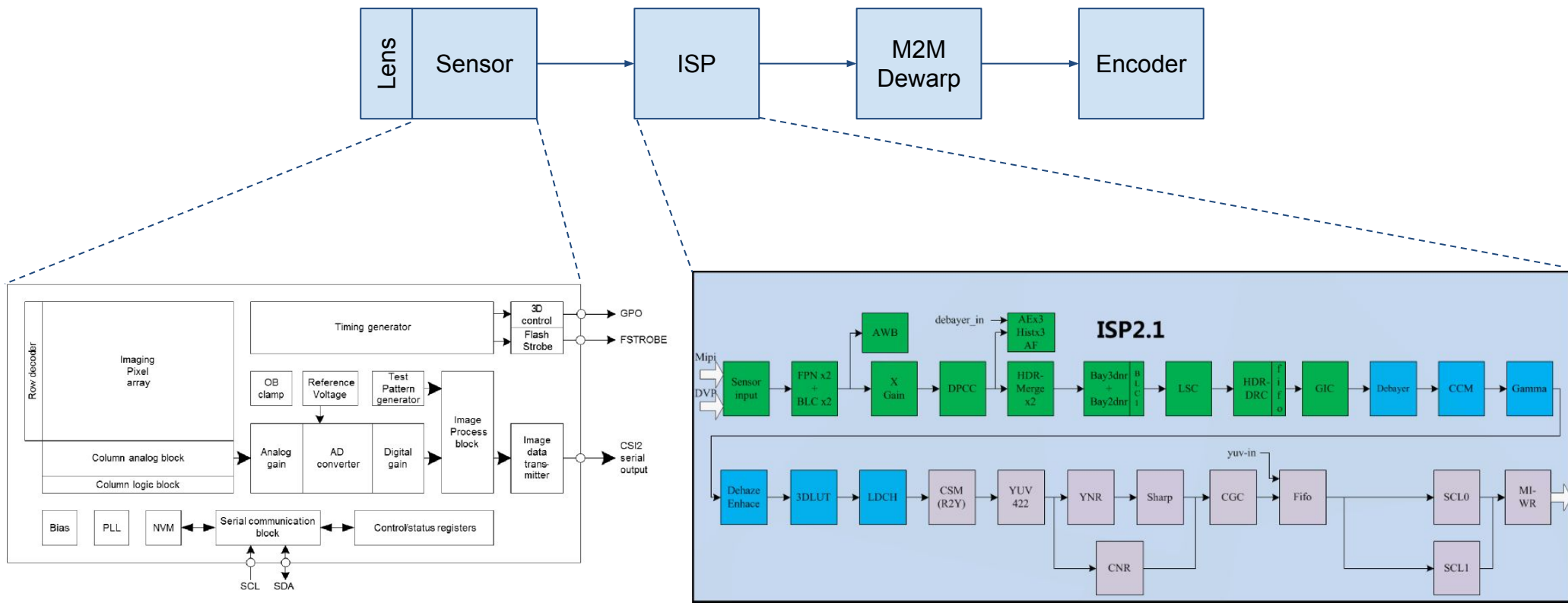


The resulting topology

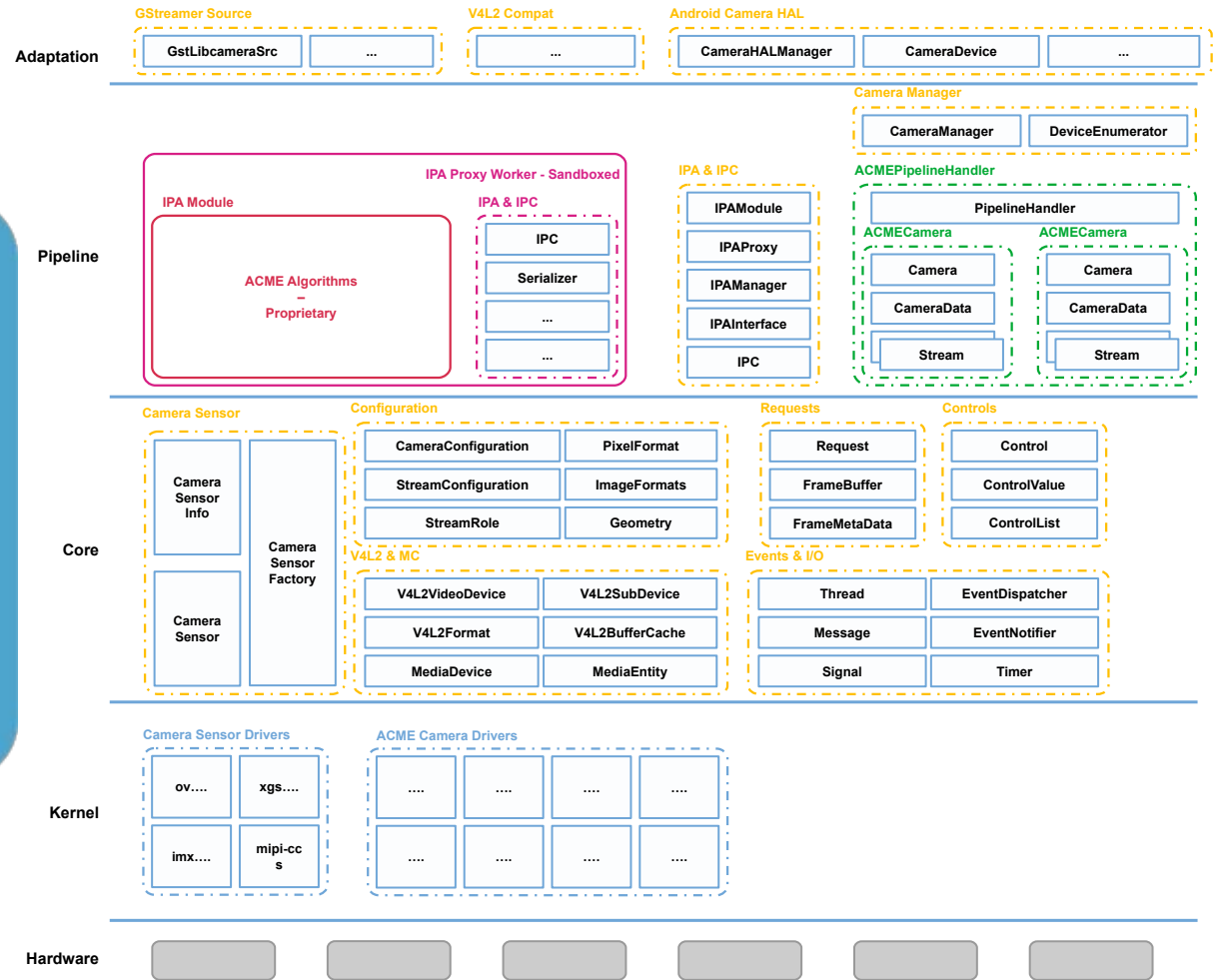
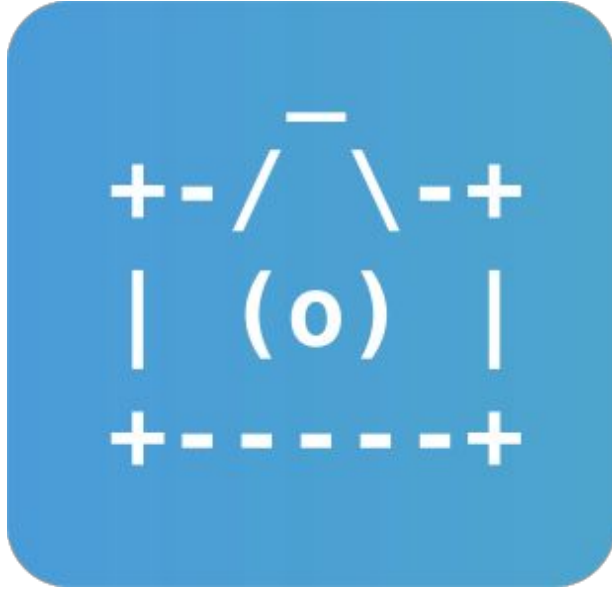
+ - / \ - +
| (o) |
+ - - - - +

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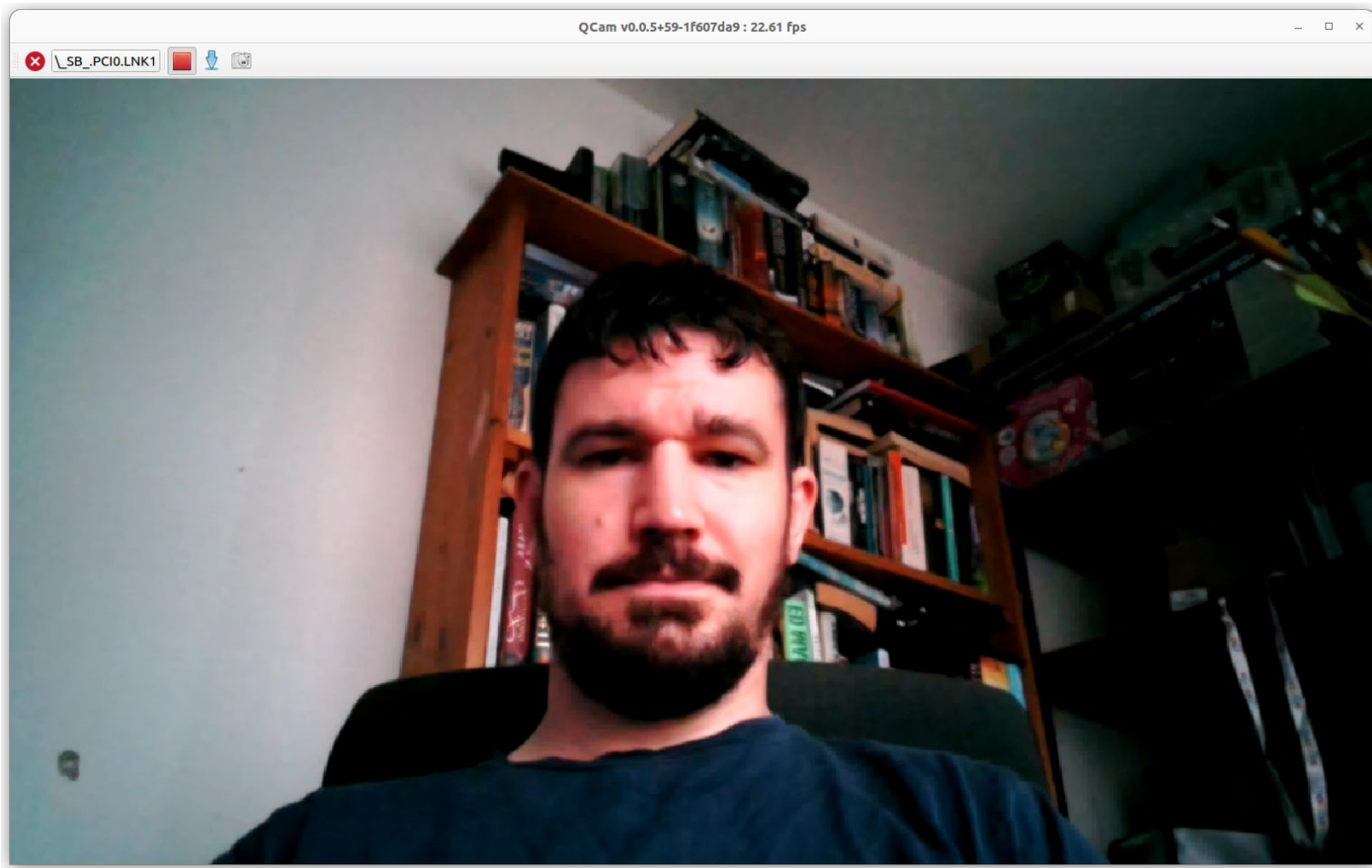




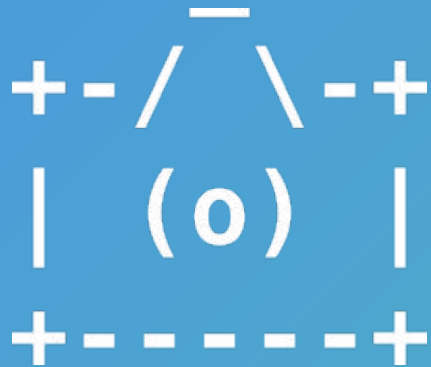
Camera Pipeline Complexity



libcamera architecture



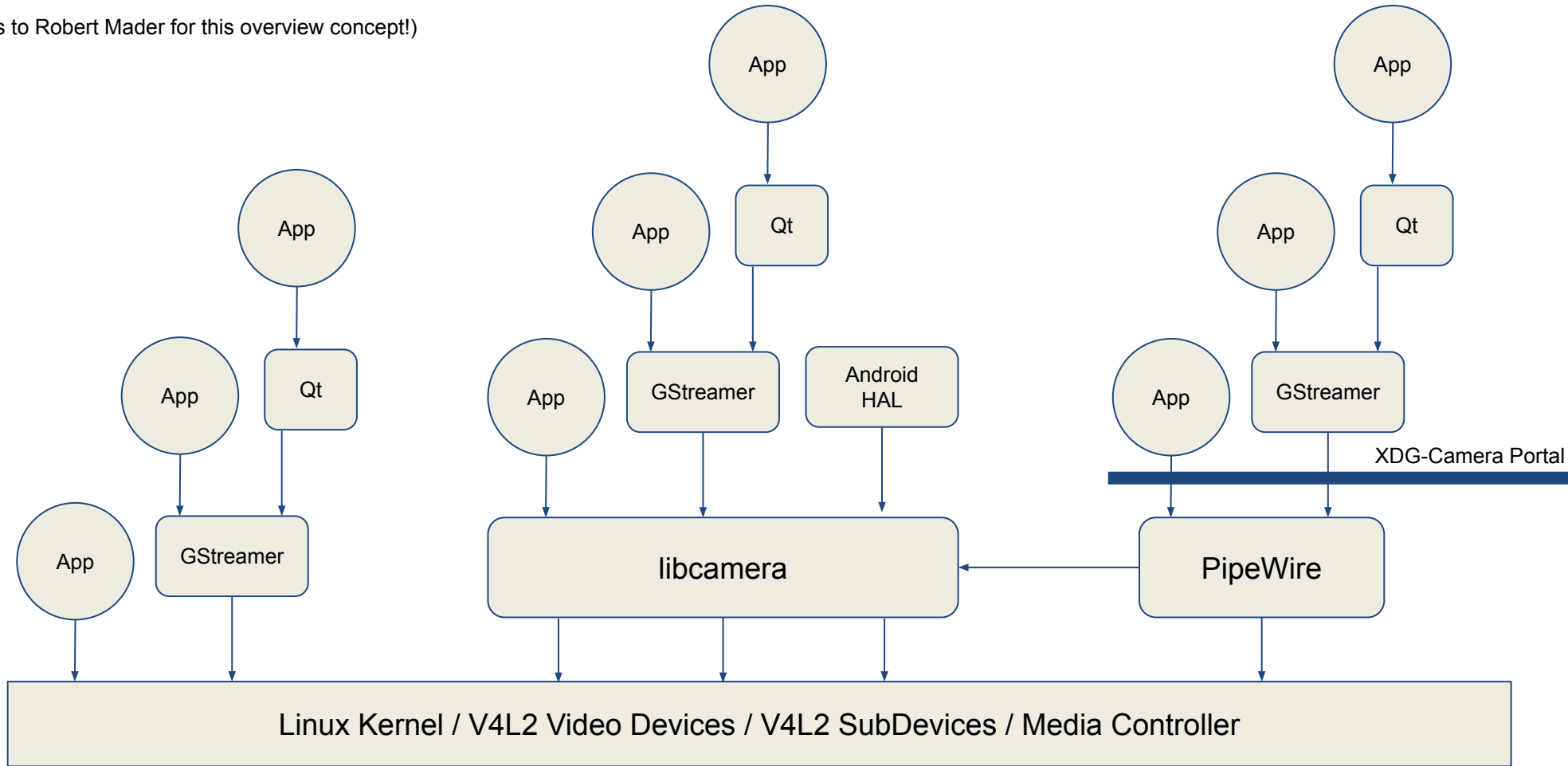
...and it works!



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(Thanks to Robert Mader for this overview concept!)



The linux multimedia camera stack

Product images are for illustration only



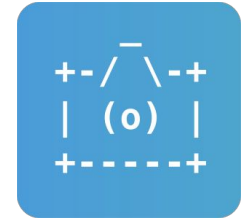
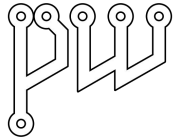
User facing devices go well with PipeWire directly or through a supported framework.



Embedded devices should usually target supporting frameworks that help with the overall use case.



Frameworks or very custom / industrial devices or applications with specific camera requirements can use libcamera natively.



So, What should I use?

**IDEAS
ON BOARD**



[libcamera-devel] py: examples: Add simple-capture-opencv.py

- Likely a good candidate for a direct libcamera implementation, *and* PipeWire support for desktop
- GStreamer pipeline support already possible through the gstlibcamerasrc
- Direct Python example now available
- We have a Google Summer of Code project actively looking at native libcamera integration now



OpenCV

192.168.0.29:8080/



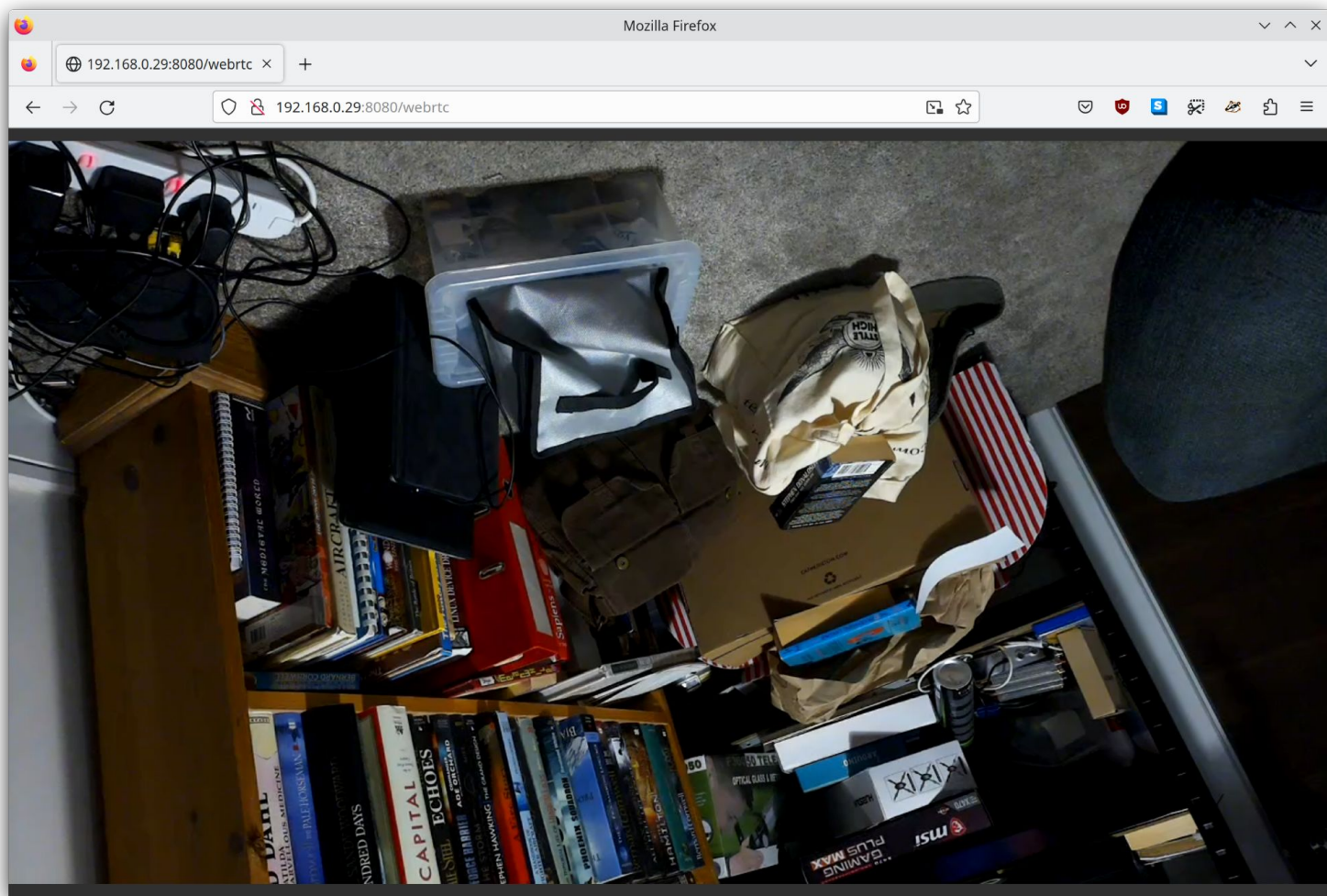
192.168.0.29:8080

- [/snapshot](#) (JPEG image)
 - Get a high-resolution snapshot image from the server.
 - Uses resolution specified by `-camera-snapshot.height=`.
 - [/snapshot?max_delay=0](#) to get a snapshot captured exactly now.
 - [/snapshot?max_delay=300](#) (default) to get a cached snapshot captured up-to 300 ms in the past.
- [/stream](#) (MJPEG stream)
 - Get a live stream. Works everywhere, but consumes a ton of bandwidth.
 - Uses resolution specified by `-camera-stream.height=`.
- [/webrtc](#) (HTTP page / iframe)
 - Get a live video using WebRTC (low-latency streaming with latency of around 100ms).
 - Uses resolution specified by `-camera-video.height=`.
- [/video](#) (IP Camera)
 - Get a live (H264) video stream best suited to current browser in a maximum compatibility mode choosing automatically between one of the below formats.
 - Uses resolution specified by `-camera-video.height=`.
 - [/video.mp4](#)
get a live video stream in MP4 format (Firefox, with latency of around 1s if FFmpeg enabled).



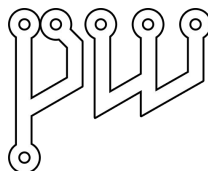
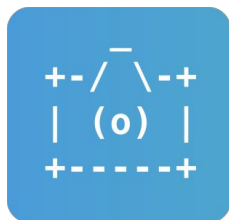
Camera Streamer

<https://github.com/ayufan/camera-streamer>



Camera Streamer

<https://github.com/ayufan/camera-streamer>



XDG-Camera-Portal



<https://flatpak.github.io/xdg-desktop-portal/#gdbus-org.freedesktop.portal.Camera>



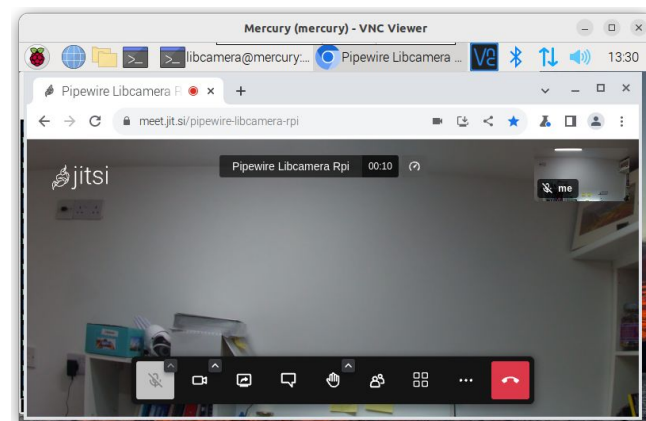
Video Conferencing with WebRTC is nearly* upstream



Technical Showcase stand :

- Embedded Linux conference Europe (Dublin 2022)

- Lacks correct format negotiation
- Stride not correctly managed
 - Affects frame sizes that are not a multiple of 32, in width. 1280x720 is usable
- PipeWire issue with multiple cameras.
 - Fixed to single camera for the moment
- Segmentation faults with RPi chromium build with the V4L2 M2M decoders.
 - A pain - but not related to the camera work



Demonstrated at the previous conference

Chromium Gerrit CHANGES YOUR DOCUMENTATION BROWSE

Search: pipewire

Subject	Owner	Reviewers	Repo	Branch	Updated	Size	Status	CR	V	CQ
Initial PipeWire audio support	Erik Jensen	Lambros ...	chromium/src	main	Jun 22	L	Merged	✓		+2
Roll WebRTC from 01a2e3d97d36 to 9dce12c8b30f1 (1 revision)	chromium-aut...	webrtc-c...	chromium/src	main	May 23	XS	Merged	✓		+2
Roll WebRTC from 4260381d1c107 to 30d120871d3d1 (3 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	May 23	XS	Merged	✓		+2
Update config and include paths for PipeWire / WebRTC	Michael Olbrich	Camille, Lambros ...	chromium/src	main	May 24	M	1 missing	+1		
Roll WebRTC from 879b0c0ee744 to 69b0c3e189123 (30 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	May 10	XS	Merged	✓		+2
Roll WebRTC from 096427e494c6 to 8856410b6d54 (2 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	Apr 28	XS	Merged	✓		+2
Roll WebRTC from 4ec56a3aa0b4 to 4beafa38d546 (1 revision)	chromium-aut...	webrtc-c...	chromium/src	main	Apr 17	XS	Merged	✓		+2
remoting: do not use webRTC portal code if PipeWire is not enabled	José Dapena ...	Salman, Yuwei	chromium/src	main	Apr 10	S	Merged	✓		+2
desktop_capturer_wrapper: Use WaylandDesktopCapturer for Wayland	Salman	Lambros ...	chromium/src	main	Apr 03	XS	Merged	✓		+2
Roll WebRTC from 74145adab5fc to 9a2938b24c4a (2 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	Mar 23	XS	Merged	✓		+2
Roll WebRTC from 74145adab5fe to 4bfe4ae4b065 (1 revision)	chromium-aut...	webrtc-c...	chromium/src	main	Mar 23	XS	Abandoned	✓		
Roll WebRTC from e94dcefb405 to d9faa73cbbc1 (1 revision)	chromium-aut...	webrtc-c...	chromium/src	main	Mar 17	XS	Merged	✓		+2
crostini: Fix audio tests (again)	Fergus Dall	Alvin, Seewai	.../platform/tast-tests	main	Mar 09	S	Merged	✓	✓	+2
UPSTREAM: ALSA: memalloc: Add fallback SG-buffer allocations for x86	Vamshi Krishn...	Curtis, Sean Paul, +1	.../third_party/kernel	chromeos-5.15	Mar 03	M	Merged	✓	✓	+2
crostini: Fix AudioPlaybackConfigurations	Fergus Dall	Alvin, jamesye	.../platform/tast-tests	main	Mar 01	L	Merged	✓	✓	+2
Video Capture Linux: factor out v4l2 camera support	Michael Olbrich	Jonathan, Tommi	chromium/src	main	Feb 21	XS	Merged	✓		+2
Adds WebRTC.DesktopCapture.IsZeroHzActive.{Screen/Window} UMA	Henrik Andrea...	Alex Coo... , Jan	chromium/src	main	Feb 06	S	Merged	✓		+2
Roll WebRTC from 97d1c3476957 to f0be3bee1fc1 (4 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	Feb 02	XS	Merged	✓		+2
container-guest-tools: Use pipewire for bullseye	Norman Binta...	Chih-Yang, David Mu... , +1	.../containers/cros-container-guest-tools	main	Feb 02	M	Merged	✓	✓	+2
Add bullseye-backports to cros.list.	Norman Binta...	Chih-Yang, David Mu... , +1	.../platform/trepllin	main	Feb 02	XS	Merged	✓	✓	+2
remoting: Support callback based frame capturing	Salman	Lambros ...	chromium/src	main	Feb 01	L	Merged	✓		+2
Roll WebRTC from a2653bc23647 to 26340b07a495 (5 revisions)	chromium-aut...	webrtc-c...	chromium/src	main	Jan 27	XS	Merged	✓		+2
[WIP] remoting: Support callback based frame capturing	Salman		chromium/src	main	Jan 19	M	WIP	○		

- <https://chromium-review.googlesource.com/c/chromium/src/+3308882>



Chromium Pipewire integration is /so/ close

https://bugzilla.mozilla.org/show_bug.cgi?id=1724900

m Bugzilla Search Bugs Browse Advanced Search >> New Account Log In Forgot Password

Copy Summary View

Closed Bug 1724900 Opened 2 years ago Closed 8 days ago

Use xdg camera portal and pipewire for webcam access

▼ Categories

Product: Core ▼
Component: WebRTC ▼

Type: + enhancement
Priority: Not set Severity: --

▼ Tracking

Status: RESOLVED FIXED
Milestone: 116 Branch

Tracking Flags: firefox116 Tracking Status: --- fixed

► **People** (Reporter: rmader, Assigned: jgrulich)

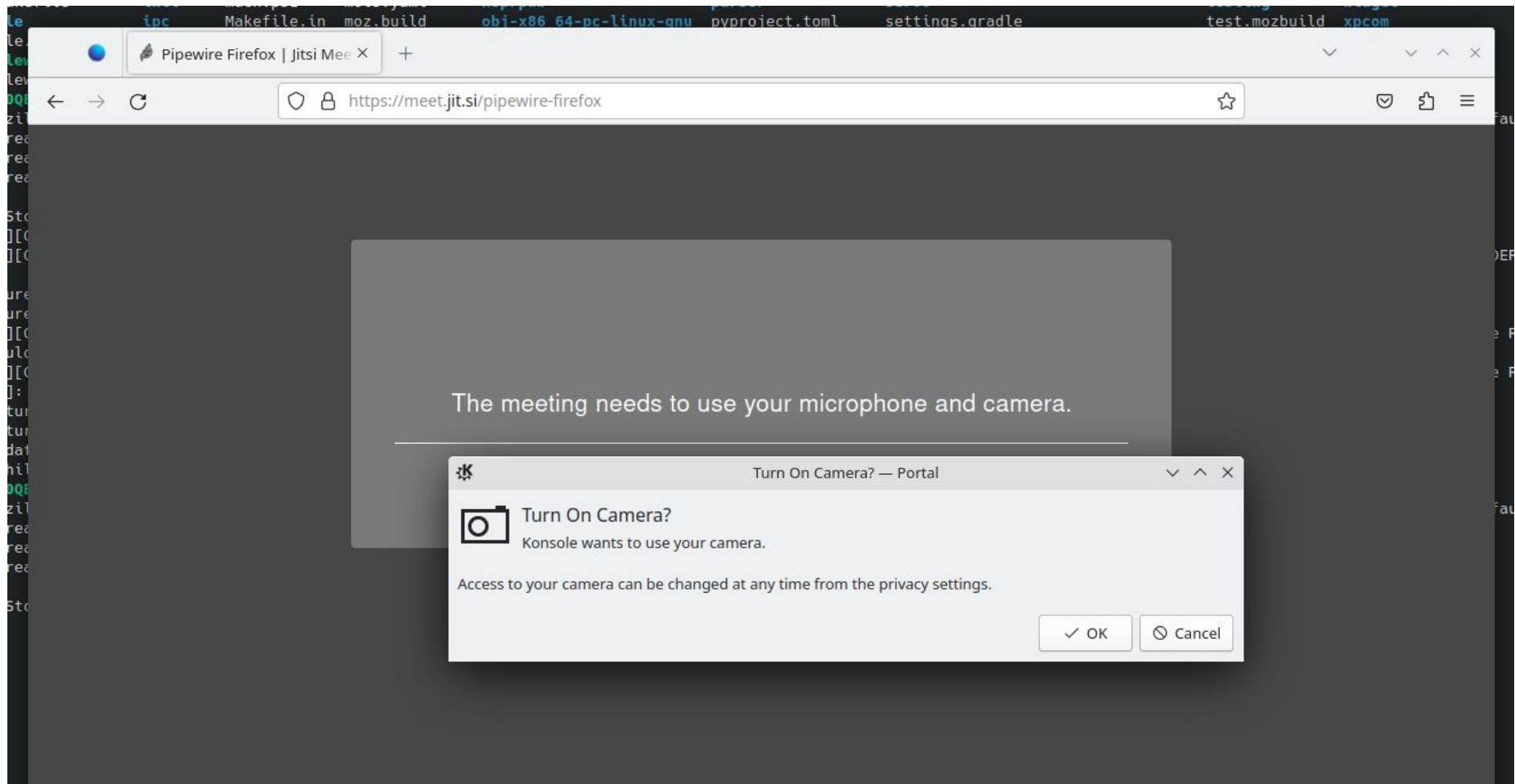
► **References** (Blocks 5 open bugs, Regressed 1 open bug)

▼ **Details**

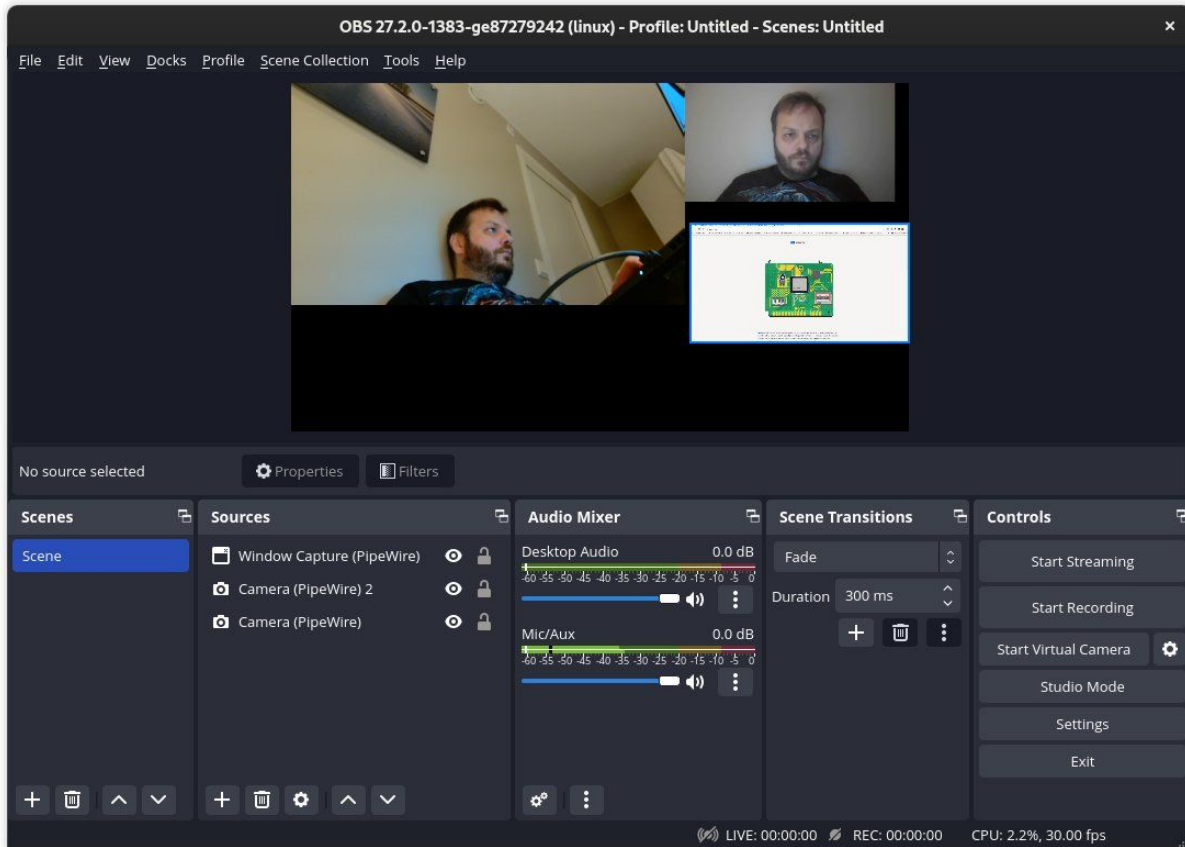
Votes: 9



Firefox support should land in 116



...it's working!



Christian Schaller
@cfkschaller

What do I see? OBS Studio capturing two different webcams using [@PipewireP](#) and [@libcamera](#)? Oh, and also PipeWire providing a capture of my browser showing the PipeWire homepage? Nice! (Using PipeWire git and [@wtaymans](#) OBS Studio git branch) [#fedora](#) [#pipewire](#) [#libcamera](#) [#linux](#)



PipeWire Project
@PipewireP

Replying to [@Fahad_Alduraibi](#) [@cfkschaller](#) and 2 others

Wim got to add the camera controls first and fix a few bugs related to camera enumeration/bring up. Then he will file a merge request. After that it is up to Obs maintainers.



Desktop PipeWire support is growing fast

Phone

Because the entire 4:3 photo needs to fit onto the view and the screen is quite tall, we need to do something with the additional height. This is done by making the headerbar taller than usual and vertically centering the buttons.



<https://www.omgubuntu.co.uk/2020/02/gnome-camera-app-mockup>

source:gitlab

On phones in landscape mode, the overall layout remains the same, but the icons/content rotates



Primary Menu

Switches between photo and video mode

TODO: Should there be a horizontal swipe gesture to switch?

Enables photo timer

Three-state toggle for flash (On, Off, Auto based on brightness)



Switch between Back/Front-facing camera

Shutter

Opens most recently taken photo in Photos
Thumbnail shows the most recently taken picture

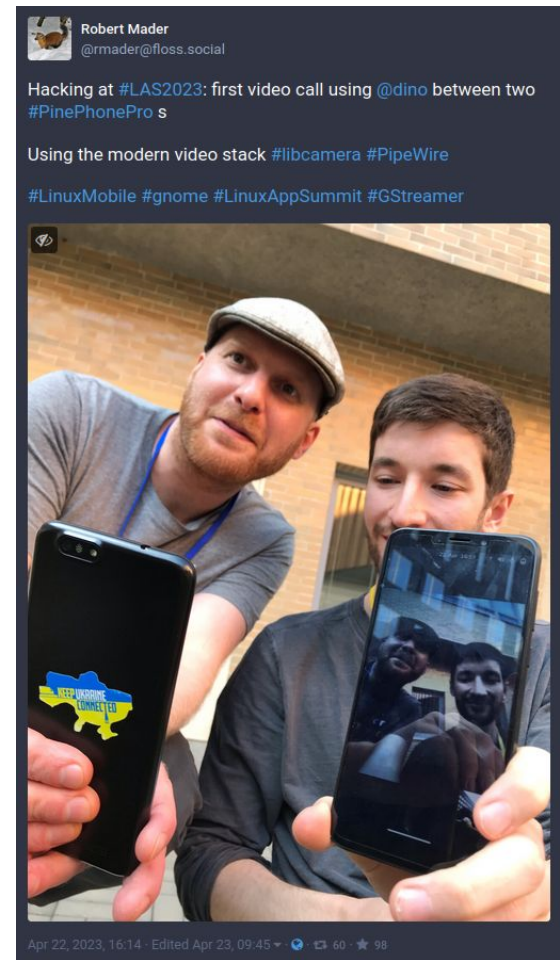
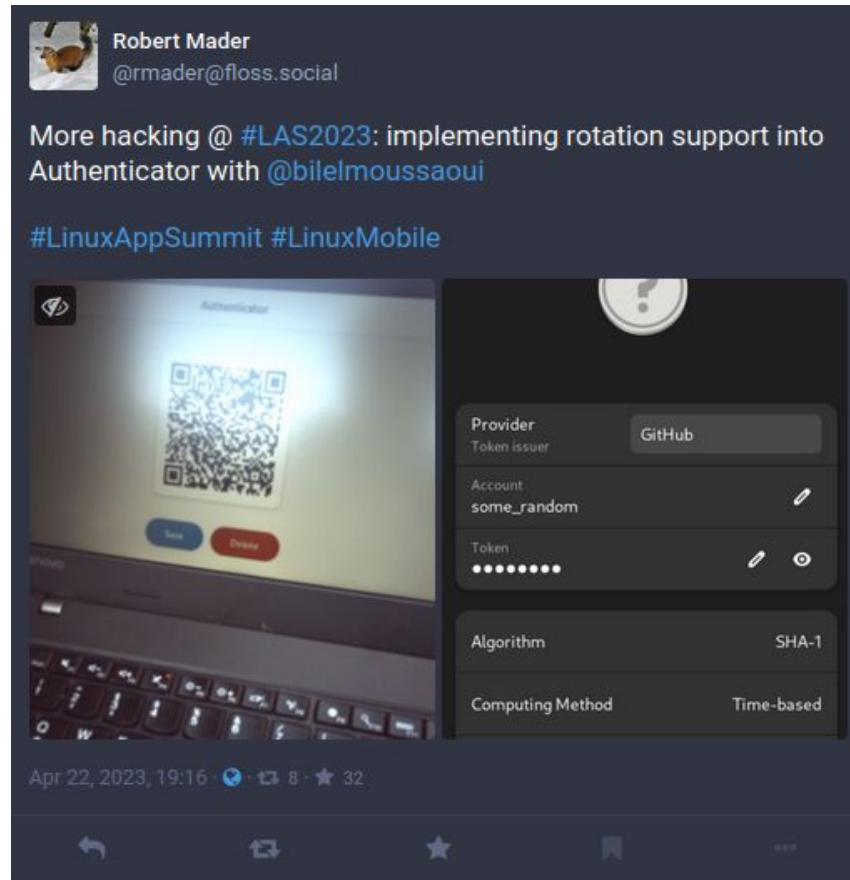
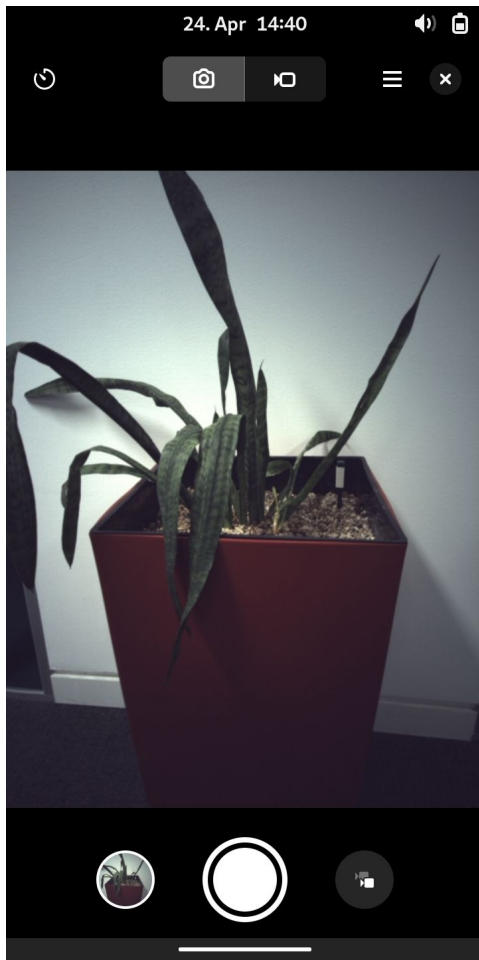


Gnome Camera App - Original Design

<https://gitlab.gnome.org/GNOME/Incubator/snapshot>



Snapshot

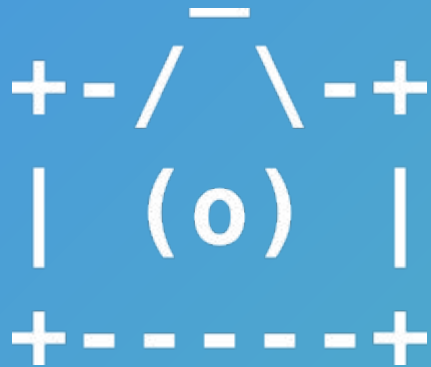


Convergent Mobile Application Support

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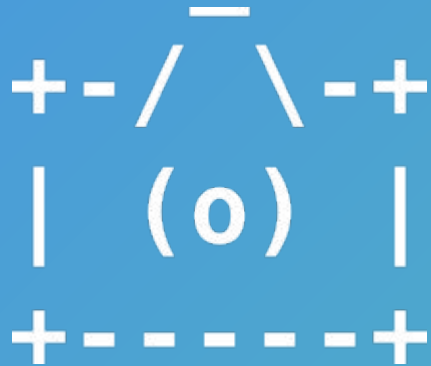
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“A bunch of smart people are using libcamera, please follow them.”

- me



libcamera

Safe Rust bindings for libcamera

by [Jurgis](#) and [3 contributors](#). Co-owned by [Dennis Shtatnov](#).

Install

GitHub (lit-robotics)

API Reference

2 releases

0.2.1 Feb 18, 2023

0.2.0 Feb 18, 2023

0.1.0 ~~Feb 5, 2023~~

#21 in [Multimedia](#)

33 downloads per month

MIT/Apache

265KB

3.5K [SLoC](#)



Dependencies

~0.7–2.7MB

~60K [SLoC](#)

- [bitflags](#) 2.0.0-rc.2
- [drm-fourcc](#)
- [libc](#)
- [libcamera-sys](#)
- [num_enum](#)
- [smallvec](#)
- [thiserror](#)

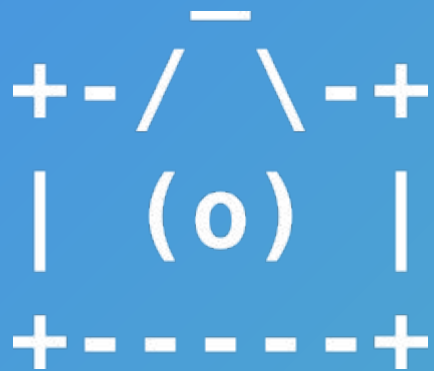
libcamera-rs



Experimental Rust bindings for [libcamera](#).



<https://lib.rs/crates/libcamera>



libcamera



<https://www.libcamera.org>
dan.scally@ideasonboard.com



Contact



?

!

**By the way, we are hiring
jobs@ideasonboard.com**

